EFFECTIVE BUCKLING LENGTHS OF COMPRESSED ELEMENTS, DETERMINED BY SAP 2000 AND ROBOT STRUCTURAL ANALYSIS

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Abstract: *Modern programs for analysis and design of building structures often have modules which can help us to determine critical values of loads in which elements will lose overall stability. These modules are especially useful for complex spatial structures where the boundary conditions are not quite clear and it is difficult to determine who is who supports (bear).*
For accurately determining the critical values of loads is very important used programs to have a correct mathematical algorithms. Unfortunately, these algorithms are not visible to us, their users. However, not everything is in foreign hands. With some simple tests we could to gain approximate idea of the reliability of the results we get.

Key words: *critical force, effective buckling length, buckling analysis*

The materials used in the construction works increase their strengths. As a result, sections of girders and columns became smaller and smaller, and elements - thinner. As a consequence of it, the elements can easily lose their local or general stability. This problem is especially relevant in modern steel structures where desire of lighter bearing elements is very strong.

Contemporary programs for analysis and design of buildings often have units (parts) which can determine the critical values of the loads. When the values of loads are critical, the elements will lose their general stability. These units (parts) are particularly useful when complicated spatial structures are analysed and it is not clear which elements bear the other one.

For correct determination of critical values of loads is very important the software that we use to have reliable algorithms for calculation. Unfortunately these algorithms are not visible for us, their users. As a result, we are left on competence, integrity and professionalism of their creators. However, not everything is in the foreign hands. With the help of some simple tests we could to have more or less clear idea about the reliability of the obtained results.

1. Introduction

For the scope of the current research we shall use two programs - SAP 2000 v.14.2 [4] and Robot Structural Analysis 2015 Pro [3]. These products are widely spread and often used by the civil engineers in Bulgaria.

For the scope of research, using these two programs, I will analyse some already solved Euler's cases for loss of stability of some centric pressed elements. The technology of analysis is as follow:

- using the relevant program is created model for analysis;
- the model is loaded by the single compressive force;
- overloading coefficient ***k*** will be considered for first form of loss of stability;
- when the introduced single compressive force is multiplied by the coefficient ***k*** , we get the value of the critical force N_{cr}. This force will cause the loss of stability of element;

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- based on well known Euler’s formulae for bearing capacity of the perfect centric pressed elements N_{cr}

(1.1) $$N_{cr} = \frac{\pi.E.I^2}{(l.\mu)^2}$$

after simple modification we can have the coefficient of shape **μ** when element losses stability:

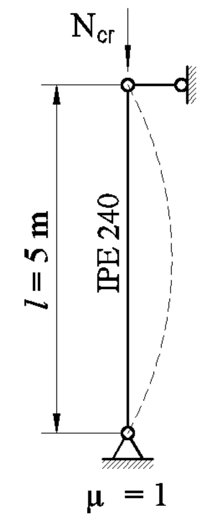
(1.2) $$\mu = \frac{\pi}{l}.\sqrt{\frac{E.I}{N_{cr}}},$$

where:
E = 21 000 кN / cm^2 is a modulus of elasticity of steel;
I – moment of inertia of compressed element;
l – geometrical length of the element.

Coefficient of shape **μ** should be researched and compared in the different cases, because:
- it is known for the classical Euler’s cases, calculated analytically;
- it depends only by border conditions of the element.

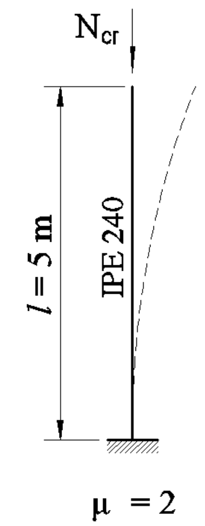
2. Research
For the research have been used some steel IPE - sections, from steel S275. Loading, supporting conditions and received results are shown bellow.

Case 1



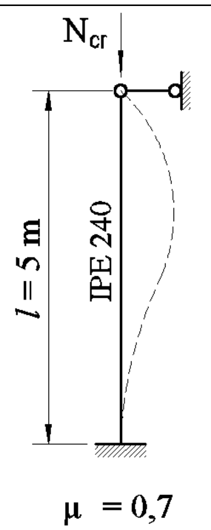
Software	Critical force N_{cr}, kN	μ	Error Δ, %
SAP 2000	3 145,5	1,012	1,2
Robot 2015 Pro	2 973,2	1,041	4,1

Case 2



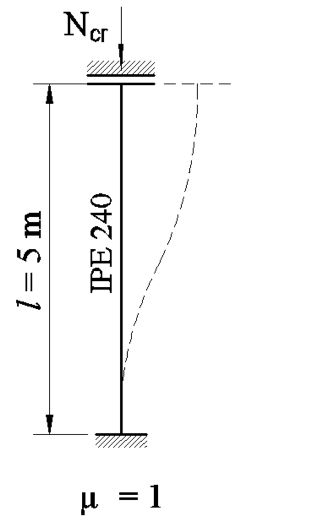
Software	Critical force N_{cr} , kN	μ	ErrorΔ, %
SAP 2000	808,2	1,998	0,097
Robot 2015 Pro	737,8	2,091	4,55

Case 3



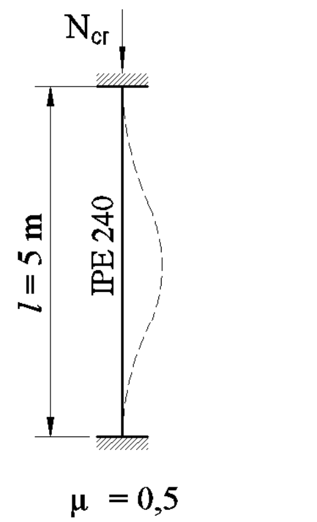
Software	Critical force N_{cr} , kN	μ	Error Δ, %
SAP 2000	6 249,6	0,718	2,57
Robot 2015 Pro	6 211,4	0,721	3

Case 4



Software	Critical force N_{cr}, kN	μ	Error Δ, %
SAP 2000	3199,8	1,004	0,4
Robot 2015 Pro	3191,4	1,006	0,6

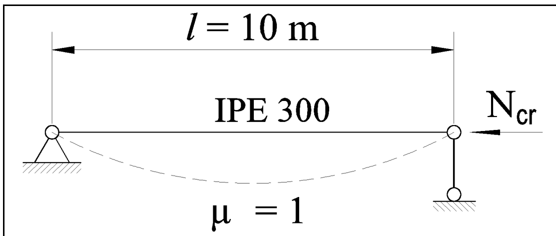
Случай 5



Software	Critical force N_{cr}, *kN*	μ	Error Δ, %
SAP 2000	-	-	-
Robot 2015 Pro	-	-	-

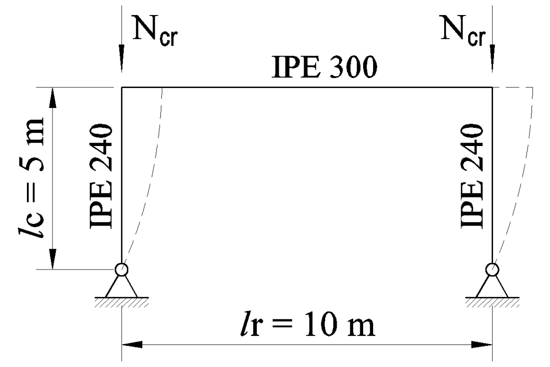
In this case both of the used programs did not succeed to calculate what will be the value of the critical force N_{cr}.

Case 6



Software	Critical force N_{cr}, kN	μ	Error Δ, %
SAP 2000	1714,8	1,005	0,5
Robot 2015 Pro	1690,7	1,012	1,2

Case7



Software	Critical force N_{cr} , kN	μ	Difference with “НПСК-87”, %
SAP 2000	601,4	2,32	0,47
Robot 2015 Pro	541,6	2,44	4,86
IPE 300 → $I_y = I_r = 8356$ cm^2 , l_r = 1 000 cm IPE 240 → $I_y = I_c = 3892$ cm^2 , l_c = 500 cm			

Case 7 is not one of the classical Euler’s cases. There coefficient of the shape **μ** for loss of stability will be calculated according to “НПСК-87” [1] :

(2.1) $$\mu = 2.\sqrt{1+\frac{0,38}{n}} = 2.\sqrt{1+\frac{0,38}{1,073}} = 2,327$$,

where:

(2.2) $$n = \frac{l_c}{I_c} \cdot \frac{I_r}{l_r}$$,

in which:
I_r, I_c are the moments of inertia of girder / column in the plane of the frame;
l_r, l_c — geometrical lengths of girder / column, see the scheme of the case 7.

3. Conclusions

Using the above mentioned programs for analysis of the structures we can make the conclusion that the obtained through them results have a good coincidence with results obtained by the analytical way. The biggest difference is less than 5% which is admissible from the engineer’s point of view. In any case the impression is that the results obtained through SAP 2000 are more precise, close to the classical one.

The determination of the critical force N_{cr} through Robot 2015 Pro always is on the way of safety, though slightly.

LITERATURE

[1]. Норми за проектиране на стоманени конструкции, отпечатани в брошура на КТСУ, С., 1987.
[2]. EULER, L., Methodus inveniendi lineas curvas maximi minimive proprietate gaudentes sive solutio problematis isoperimetrici latissimo sensu accepti. Lausanne, Geneve: Marc-Michel Bousquet & Co., 1744.
[3]. Robot Structural Analysis 2015 Pro., Autodesk, Inc.
[4]. SAP 2000 v.14.2. Structural analysis program. Computers and Structures, Inc., USA.